SPACE DENSITIES FOR POWERFUL RADIO SOURCES IN THE LIGHT OF UNIFICATION

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As radio survey frequency is raised the proportion of flat-spectrum sources increases in bright flux-limited samples (*eg* Wall 1994, *Aust J Phys* **47**, 625). Differential source counts show a corresponding broadening of the central maximum due to the increasing proportion of flat-spectrum sources. Orr & Browne (1982, *MNRAS* **200**, 1067) modelled this change in shape of the source count by proposing a unifying scheme which states that the core-dominated, flat-spectrum radio sources are the steep-spectrum sources with their cores Doppler-boosted due to the alignment of the jets with the line of sight.

Investigation of the space densities of radio sources should proceed with populations which are physically delineated; in the face of unified models, the traditional division into 'flat-spectrum' and 'steep-spectrum' populations is incorrect. To this end we are undertaking a new space-density analysis to explore the implications of unified-model schemes, including both the radio-loud QSO – FRII radio-galaxy paradigm and the BL Lac – FRI radio-galaxy paradigm (see Urry and Padovani 1995, *PASP* **107**, 803). To test the formalism, our first stage described here uses (1) complete samples and source-count data over a wide frequency range and (2) optimizing techniques to explore *parameterized* evolution and beaming models.

This initial analysis followed the scheme developed by Wall *et. al* (1980, *MNRAS* **193**, 683). Together with a 151-MHz source-count, the 162 steep-spectrum sources in the 3CR sample (Laing *et. al* 1983, *MNRAS* **204**, 151) were used to define the epoch-dependent luminosity function of the 'parent' population. The best-fit parameters were determined using the *AMOEBA* downhill simplex method in multidimensions (Press *et. al* 1992, *Numerical*

Recipes in Fortran (CUP), 402), evaluating χ^2 between the observed and model source counts. For evolution of the form $exp(M(1-t/t_0))$ the optimal parameters ($\Omega = 1, h = 0.5$) are M=10.92, z_c=4.075 and transition powers between evolving and non-evolving sources at $\log_{10}(P_1) = 25.33$, $\log_{10}(P_2) = 27.57$. This demonstrates that modern data comprising complete redshifts for the 3CR sources plus a deep source count *require* a redshift cut-off in the space density for steep-spectrum sources.

These parameter values and a single spectral index of -0.75 were used to estimate the 5 GHz count of steep-spectrum sources (Figure 1). Inclusion of the flat-spectrum, beamed population at 5 GHz was achieved with two additional parameters, the Lorentz factor γ and the rest frame core-to-extended flux ratio R_c. The observed core-to-extended flux ratio R_{obs} is given by $R_{obs} = R_c([\gamma(1-\beta\cos\theta)]^{-2+\alpha_{flat}} + [\gamma(1+\beta\cos\theta)]^{-2+\alpha_{flat}})$ for a source comprising a pair of continuous relativistic jets with bulk plasma velocity βc whose ejection axis is aligned at a random angle θ ($\geq 0°, \leq 90°$) to the line of sight. We adopted $\alpha_{flat} = 0.0$, and took a source as being 'flat-spectrum' for small enough values of $\theta < \theta_c$ such that $R_{obs} \geq 1.0$ and its observed flux density $S_{enhanced} = R_{obs}.S_{\nu_1}$. For $\gamma = 10.0$ and $R_c = 0.02$ ($\theta_c = 8°$), the count of flat-spectrum sources summed with the steep-spectrum source count closely follows the observed count (Figure 1).

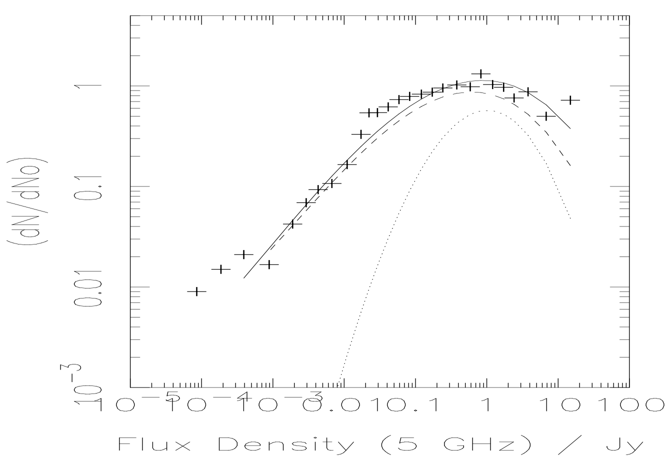

Figure 1. Model and observed source counts at 5 GHz:
++++ observed source count, - - - - model count for steep-spectrum objects, · · · model count for flat-spectrum objects, —— total model source count.

This initial analysis demonstrates that (a) a diminution in the space density of 'parent' sources at redshifts above 4 is required, and (b) the FRII – radio-loud QSO unified scheme is consistent with the high-frequency count data for reasonable beaming parameters.